

The Middle East's Next Nuclear State

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Strategic Insights is a quarterly electronic journal produced by the Center for Contemporary Conflict at the Naval Postgraduate School in Monterey, California. The views expressed here are those of the author(s) and do not necessarily represent the views of NPS, the Department of Defense, or the U.S. Government.

Introduction

The term “nuclear renaissance” is inappropriate when talking about the Middle East: there is not a single nuclear power reactor operating in the region. Nevertheless, no less than 13 countries have announced plans of intentions in this area between February 2006 and January 2007.^[1] Growing energy and fresh water needs, as well as rising oil and gas prices, are mentioned as rationales. However, for many of them, the Iranian nuclear program is a key driver, and there is legitimate concern that some Middle East countries are interested in a weapons option. The discovery of the Al-Kibar reactor in Syria, as well as the extraordinary measures taken by Damascus to conceal its program, have heightened these fears. While concerns about the risks of proliferation in the Middle East have proven exaggerated in the past, there are good reasons to believe that they are now increasing—notably because of the dissemination of nuclear technology and of the Iranian factor.

The following analysis is an attempt to predict which Middle East countries are the most likely to go nuclear after Iran.^[2]

Assessing the Proliferation Risk in the Middle East

The Technical Angle

The HEU way

There is no known uranium enrichment capability in the Arab world or in Turkey, despite the possibility that the Khan network may have had other customers than Iran and Libya. Some countries in the region have voluntarily renounced enrichment, such as the United Arab Emirates, Saudi Arabia and Bahrain. If the Saudi concept of a Gulf Cooperation Council (GCC) enrichment consortium was to materialize, it would be outside the region. To be sure, several key Middle East States such as Syria, Egypt or Algeria will not want to commit themselves to forego enrichment. However, due to their limited resources and the probable political costs, it is dubious that any of them will embark in an open, industrial-scale enrichment project. The worst that can be expected in the short-to-medium term is a small, hidden enrichment plant based on past Pakistani transfers. It is dubious that Iran will itself transfer its technology in this area—except perhaps to Syria. Also, there is no significant research reactor in the region that operates with highly enriched uranium, which may create a proliferation risk.

The plutonium way: research reactors

One option for a would-be nuclear aspirant in the Middle East would be to use a research reactor. Some of them are particularly well-suited for that purpose. Graphite-moderated and heavy-water-moderated reactors can be fuelled with natural uranium, thus optimizing their Pu-239 production potential. The fuel can be discharged without stopping reactor operations. Research reactors using enriched uranium as fuel can also be used for producing plutonium. However, they are generally less efficient for such a purpose and require techniques such as “blanketing” the reactor core with natural uranium. Outside Iran and Israel, three countries in the region have a reactor of a decent size, which also happen to be high neutron flux reactors, making them fairly efficient for plutonium production. However, none of them has the size required to make a significant quantity (SQ) of plutonium in no more than a year. The International Atomic Energy Agency has determined that it was not possible to produce 8 kilos of plutonium in a research reactor of less than 25 MWth. None of the Middle Eastern countries reactors is above this limit. Producing plutonium in a known research reactor would thus be an option only for a country willing to break with the IAEA inspections regime.

The plutonium way: power reactors

Using power reactors to produce military-usable plutonium will not be accessible to Middle East countries before 2015-2020, and is hardly an attractive option. It is reasonable to assume that power reactors in the region will be light water-moderated. The isotopic composition of the fuel irradiated in such reactors (which is generally withdrawn after some 4-5 years) is ill-suited for making bombs. It has a low content of Pu-239 (some 55-60%). Because it is conversely rich in Pu-240, it would make for highly unreliable weapons. Furthermore, the intense heat and radioactivity of such irradiated fuel would make it particularly difficult to handle. The only realistic option would be to use “low burn-up” material, that is, those fuel rods which have been irradiated only for a short period of time. For instance, using the rods that have stayed in the reactor for only one “cycle” (about 18 months) would contain only some 14% Pu-240. The material would be weapon-usable. According to one analysis, using technology equivalent to that of the United States in 1945, it would be possible to make for weapons that would have 70% probability of achieving a 1-kiloton yield.^[3] But such activities would be detected by the IAEA. And the country’s fuel supplier would probably stop deliveries, which would imply stopping the reactor’s operation (with possible social and economic consequences). There are other, more cost-effective options for country willing to embark in a nuclear military program. So far, there is no coincidence between power production programs and weapons production programs. Most countries producing nuclear-generated electricity do not have nuclear weapons. Several nuclear weapons programs have been initiated without any power reactor in the country (North Korea, Iraq, Libya, Israel).

Plutonium separation

Outside Israel, there is no known plutonium separation installation in the Middle East. As in the case of uranium enrichment, several countries in the region have already committed themselves to forego such installations. However, others (Egypt, Algeria, Syria, Libya, and to a lesser extent Saudi Arabia) have hot cells at the experimental level. They could conceivably develop a separation capability in a relatively short period of time.

Economic aspects

It is likely that the development of civilian nuclear programs in the Middle East will be a slow-motion process. The magnitude of projects and intentions announced by countries in the region is striking. According to an internal study made by the French firm Areva in 2008, there are no less than 30 “proposed” (26) or “ordered” (4) reactors in the Middle East and Africa. Such plans are unrealistic. The international suppliers, which have reduced their capabilities in the 1990s after the Chernobyl accident, cannot meet such a growth in demand. Their preference will thus go to countries which already have a well-endowed nuclear infrastructure, and then only to Middle East customers—choosing those who are the most willing and able, such as the UAE. Most Middle East countries will not be able to satisfy the financial, legal and infrastructure requirements of nuclear power plants before a long time.

Setting up a small military-dedicated nuclear program remains, however, accessible to most Middle East countries. North Korea is poorer than the vast majority of them. Syria and Egypt, for instance, which are not among the richest States of the region, are perfectly able to afford one. (See [Table 1](#).) Access to a dedicated research reactor, plutonium separation installation, or a small uranium enrichment plant will thus largely depend on the availability of the main nuclear suppliers and on their willingness to “close their eyes” to proliferation risks. Another possibility is resorting to “rogue suppliers,” such as North Korea (the Syrian case being of course a case in point) and perhaps in the future Iran (IR-2 or IR-3 centrifuges would make it possible to build a small facility forming the basis of a breakout option)—and of course to private expertise, such as a reconstituted enrichment supplier network.

The state of safeguards

The IAEA safeguards system is seriously deficient in the region. A majority of countries in the region do not have an additional protocol into force, including Algeria, Egypt, Saudi Arabia and Syria. In addition, most of the Middle East countries which benefit from a Small Quantities Protocol (SQP) have yet to accept the 2005 amended version, which states that an SQP ceases to be applicable as soon as a nuclear installation is planned. Such deficiencies are all the more serious since photographic examination of the Al-Kibar site in Syria shows that some countries may resort to extraordinary camouflage and deception measures to hide sensitive nuclear activities.^[4]

Conclusions

Good news and bad news can be inferred from the above analysis. The good news is that national projects announced in recent years by Middle East countries will take a long time to come to fruition, and will have little direct usefulness for military purposes. For political and economic reasons, it is unlikely that any Middle East country will build, in the next 10 years, fuel cycle installations that would give it an overt breakout option (industrial-size reprocessing or enrichment plant). The bad news is that there are real causes for concern:

- Some determined countries might secretly acquire or develop small, undeclared facilities dedicated to plutonium production and separation, or to the production of highly enriched uranium. The financial cost would be bearable to most countries. In the absence of an additional protocol, such an option would be available to States such as Algeria, Egypt, Saudi Arabia, or Syria.
- Among the installations known to the IAEA, some reactors such as Es-Salam in Algeria or Inshas in Egypt could be used to produce military-usable plutonium. To be easily and

fully exploitable, such an option would require ending Agency controls, or benefiting from a break-up of the NPT regime.

- Civilian nuclear programs will contribute to the development of scientific expertise and technical know-how. They could also be useful to mask the existence of military-dedicated activities.
- Regional cooperation or a “division of labor” between several Middle East countries (e.g. Syria/Iran, Egypt/Saudi Arabia, several GCC countries...) would significantly diminish the time needed for them to develop a military option as well as the risks of being discovered.

The Strategic Angle

The security dimension

When the scope of the Iranian nuclear program became publicly known in 2002-2003, the idea that it could be a stabilizing factor in the region was still fairly widespread.^[5] Unease started to grow in 2005 with the radicalization of Iranian policy and the break-up of the negotiating process. The Iraqi insurrection and the war in Lebanon heightened the fears of a Shi'a regional revival which may be supported by Iran. The GCC proposal for a WMD-free zone in the Gulf (December 2005) was a clear signal that the Iranian program was much more a problem for them than the Israeli program.

The evolution of Western security guarantees in the region will certainly be a key parameter to determine the actual risks of further proliferation, and the Middle East is no exception to this logic.^[6]

However, only Turkey benefits from a clear-cut, formal and legally-binding Western security commitment. U.S. defense agreements with Gulf countries (which have not been made public) do not contain any constraining defense commitment, according to an authoritative analysis.^[7] (The same can be said for British and French security agreements with several small Gulf States.) As they have not been formalized in a treaty, they can be revoked at any time. Furthermore, there is no equivalent in the region to the North Atlantic Treaty Organization. Also, some countries such as Egypt do not benefit from any security commitment despite its status of Major Non-NATO Ally since 1989. To be sure, the United States is seeking to deepen its strategic relationship with the GCC countries. Washington has announced its intention to increase its military equipment sales to these countries (2007), and to develop their missile defense capabilities.^[8]

A broad array of agreements was signed with Saudi Arabia at the occasion of the 75th anniversary of the establishment of diplomatic relations between the two countries.^[9] A new “Carter doctrine,” that is, a solemn, public pledge to defend allies in the Middle East in light of the Iranian threat could dampen nuclear appetites in the region.^[10] At the same time, the countries concerned may not wish to see such a public commitment. It could be seen by some parts of their elites as an act of “colonialism.”^[11] It could also be disapproved by public opinions, which consider Israel and the United States as a much bigger threat than Iran.^[12] Finally, even reinforced assurances would not alleviate the concerns of the Gulf countries. After the Iraqi adventure, they may fear that the United States will not have the stomach for another massive military operation in the region. And assuming Iran gets the Bomb, it will be difficult to convince them that the West will be ready to resist—given that, by definition, it would have been unwilling or unable to stop it from doing so.

The political angle

Not unlike Pakistan in the past—but in a much more publicized way— Iran has succeeded in making its nuclear program being seen as a symbol of sovereignty, modernity, and prestige. This may appeal others to proceed along the same path. In addition, some analysts note that events in the region since 2001 have resulted in *“unprecedented severe criticism of Arab leadership by Arab citizens, Arab media and Arab intellectuals, which has motivated some Arab leaders to publicly discuss plans of nuclear acquisition to restore the appearance of strength and independence.”*^[13] The symbolic value of nuclear programs is thus particularly strong in the region. As former UN Secretary General Kofi Annan noted in a private conversation about Iran, *“It is a matter of pride. Like having a Porsche or a Jaguar.”*^[14] Of course, a nuclear military option would fully play such a role only if it was openly exercised. However, even in secret, a nuclear program can be a way to bolster the domestic legitimacy of the leadership, be it a “son of” (such as Bashar El-Asad in Syria, or Gamal Mubarak in Egypt), or the armed forces (such as in Turkey, or Algeria).

Opportunity costs

In current circumstances, it is highly dubious that existing Middle East regimes will decide to conduct openly military-related nuclear activities, which would imply withdrawing from the NPT. The political costs—and the associated costs in terms of sanctions—would be too high. The only realistic option would be to conduct secret activities. The Israeli bombing of the Syrian reactor in September 2007 has confirmed that the use of military force could be, in some cases, a viable option for treating a nuclear proliferation problem created by a secret program. The Israeli decision was certainly not taken lightly. One has to remember that there were heated debates within the Israeli cabinet on the wisdom to strike the Iraqi reactor in 1981. But the result is clear. And military preparation in the summer of 2007 show, in retrospect, that the country was ready to risk war with Syria. All this could give pause to a future would-be Middle East nuclear aspirant. At the same time, the same aspirants will have taken note of the fact that Syria suffered no other consequences than the loss of its reactor for having embarked in such an adventure.

Conclusions

Taking into account all factors that are likely to come into play in the strategic calculus that Middle East countries will make in the future, it seems that the nuclear temptation will indeed be strong. What follows is an attempt to determine which countries are more likely than others to go down the nuclear path.

Countries of Particular Concern

An overview of the nuclear landscape in the region reveals a very diverse picture. Egypt, Algeria and Turkey have significant nuclear activities. The first two may have attempted to embark in a full-fledged military program in the past, while the third is a NATO member. Syria, an ally of Iran, was generally considered a serious nuclear proliferation risk, but the revelation of the Al-Kibar reactor has altered this assessment. Saudi Arabia, an ally of the United States, has almost no known nuclear activity but is widely believed to be a leading candidate when assessing future proliferation risks in the region. Libya maintains a small nuclear program but has “recanted” and does not face any major security threat. Iraq was once considered the number one nuclear threat in the region but has been stripped of any serious capability. Morocco is an emerging player. Jordan, Tunisia and the United Arab Emirates are willing to develop a nuclear program. The seven remaining countries have no nuclear research program and few serious plans in this area.^[15]

Algeria

Because of its open support for Iran, of the existence of a significant national nuclear program which has raised suspicions in the past, and because it still does not have an additional protocol into force (even though it was approved by the Board of Governors in 2004), Algeria is clearly a country of concern. Algeria has a fairly developed nuclear infrastructure, which can be compared to that of Egypt. It includes two nuclear reactors as well as a small fuel fabrication plant. It also has significant technical and scientific competences, notably within the *Centre des sciences et de la technologie nucléaire* (CESTEN). Its Es-Salam 15MWth reactor, operational since 1992, raises proliferation concerns : (1) Its construction in secret in the 1980s by China, in a desert area, at some point protected by anti-aircraft batteries ; (2) Its particular characteristics, which make it rather well-suited for military applications : a high neutron flux reactor, moderated with heavy water.[16] Some fuel rods may have been withdrawn without IAEA having been notified.[17] Questions about the Algerian nuclear program are all the more relevant since cooperation with China has continued throughout the 1990s, including through the sale of hot cells.[18] (Algerian interest for hot cells was confirmed at the occasion of an official visit to South Korea in 2006.)[19] The status of Algerian plutonium separation capabilities is uncertain.[20] It has been qualified as “dormant” by knowledgeable analysts.[21] In the absence of an additional protocol, it is not certain that the IAEA is able to verify all Algerian nuclear activities. It also has been noted that there were very few Algerian publications in this field despite a fairly large number of scientists and engineers working on nuclear issues.[22] Of course, Algeria does not have any immediate reason to launch or re-start military-related nuclear activities. Despite troubled relations with some of its neighbors (Libya, Morocco), it does not face any significant and immediate military threat. However, for status reasons, it may not want to leave Egypt or Saudi Arabia become the “first Arab nuclear power.” A nuclear program may also contribute to strengthen the armed forces’ control on political decision-making, as has been the case in Pakistan.

Egypt

Cairo has announced its intention to relaunch its civilian nuclear program. Its rapid electricity consumption growth, dwindling oil resources, and strategic location which makes its grid connected to the two transnational regional electricity networks, make it well-placed to be a future regional leader nuclear electricity generation, despite financial difficulties.[23] Egypt’s longstanding nuclear experience makes this ambition credible. It has two research reactors, including a high-neutron flux Multi-Purpose Reactor (MPR) located at the Inshas research center. The 22MWth MPR could produce 6.6 kilos of plutonium a year assuming 300 days of operation.[24] Egypt also has since 1998 two fuel-making installations, a laboratory (Semi-Pilot Fuel Laboratory, SPFL) and a full-fledged plant (Fuel Manufacturing Pilot Plant, FMPP) which fabricates fuel for the MPR reactor. It also has significant uranium reserves. As is now known, Egypt has made experiments that could be useful to a military program, before and after its safeguards agreement came in force (1982). These involved the production of uranium metal, irradiation of natural uranium targets, and chemical dissolution of fuel elements.[25] The Atomic Energy Agency (AEA) has hot cells which could be used for experimental plutonium separation, located at a dedicated facility (Hot Laboratory and Waste Management Center, HLWMC).[26] It has no intention to forego sensitive fuel cycle activities: for Cairo, this could only be an acceptable option if it concerned “the whole region.”[27] Egypt is thus one of the only Middle East countries which could envision a full-fledged, autonomous nuclear program. Despite the apparent abandonment of military-related projects decades ago, President Mubarak has stated several times in oblique terms that the option remains. Cairo has three potential motivations for a military program: (i) It considers itself as a leader—if not the national leader—of the Arab world, and both the rise of Iranian influence and the activism of Saudi diplomacy probably give Cairo reasons to consider its options to bolster its regional status; (ii) On the longer run, Iran could be considered a potential threat, given its support for militant movements in Lebanon, the West Bank and especially Gaza; (iii) A nuclear program may have domestic political benefits: the Muslim

Brotherhood openly favors such an option, ostensibly to “balance” the Israeli program.[28] Cairo refuses to sign the additional protocol, arguing that it is a voluntary measure which would be unacceptable to subscribe to given that Israel has not even signed the NPT.[29] It could thus conceivably conduct military-related activities with a low risk of detection—banking on the fact that Israel would not dare striking military-dedicated activities in Egypt, who contrary to Syria is technically at peace with its neighbor and is one of the few Middle East countries recognizing its existence. However, in current circumstances Cairo will refrain from any risky move, since it would put at risk the two pillars of its security (peace with Israel and U.S. assistance) while the political benefits would be limited if existing at all, because the program would be secret.

Libya

Libya's nuclear program has been reduced to its civilian research component. However, Tripoli retains significant infrastructure and expertise, which would be useful if the country wanted launch a military program again. Its IRT-1 has been operational since 1981. It is a high neutron flux reactor, but one whose plutonium production remains limited because of its power (10 MWth). 20 kilos of HEU stocked at Tajura have been taken to Russia and the United States, and the reactor is being converted to use LEU as fuel.[30] The Tajura Nuclear Research Center (TNRC) also comprises a number of experimental facilities: a 100 W neutron generator, a TMA-4A tokamak, and hot cells. Numerous undeclared experiments of uranium targets irradiation were conducted at Tajura between 1984 and 1990, with the production of small quantities of plutonium.[31] There is no indication today that Libya could be willing to embark again in a military program, and the country enjoys rather good relations with Algeria and Egypt. However, Tripoli is keen on maintaining its expertise.[32]

Saudi Arabia

Saudi experience in the nuclear field is extremely limited. The *Atomic Energy Research Institute*, (AERI), established in 1988, et le Nuclear Engineering Department of King Abdul Aziz University, founded in 1977, conduct research on the use of nuclear energy for water desalination and medical treatment. The King Faisal Hospital has a small cyclotron and five hot cells.[33] The AERI has four laboratories working on separation of elements.[34] Having joined the NPT only after the controversy over its acquisition of Chinese CSS-2 missiles (1988), Saudi Arabia remains the only significant IAEA member which does not have a comprehensive safeguards agreement in force. This is not necessarily a cause for concern—Saudis are not keen on having international inspections on their soil for religious reasons—but it would allow the country to embark in clandestine activities with a low risk of detection. Saudi leaders are extremely worried about the Iranian nuclear program, and the country's diplomacy is trying both to limit Shi'a influence in the region while maintaining a dialogue with Tehran. Like in Israel, Iran is frequently described as an “*existential threat*.”[35] The prestige in the Muslim world of an Iranian Bomb could be a “*political humiliation*” for Riyadh.[36] Perhaps the country could live with an Iran at the threshold; but an overt capability, including withdrawal from the NPT and maybe a nuclear test, would be unacceptable to Saudi Arabia and force it to reexamine its strategic options.[37] Credible sources have indicated that Saudi authorities have envisaged three options (which may not be alternatives): acquisition of nuclear weapons, alliance with a nuclear power, and promotion of a nuclear-weapon-free zone.[38] Prince Turki has implicitly confirmed the existence of the document.[39] According to U.S. ambassador Chas Freeman, en 2003, King Fahd demanded a nuclear guarantee to the United States in case Iran did obtain nuclear weapons.[40] But lack of trust between the two countries may push Riyadh to look for other avenues. Saudi Arabia fears an arrangement between Washington and Tehran which would lead to a greater Iranian role in the region.[41] And it could also seek a nuclear deterrent to prevent a hypothetical future U.S. operation against its own territory—for instance after a second 9/11 type attack.[42] There are persistent rumors of a possible Saudi-Pakistani understanding on these issues, and the Saudi 2005 request to the IAEA for a Small Quantities Protocol has heightened suspicions. It is reasonable to assume that discussions of nuclear cooperation have taken place between the two

countries (as well as discussions on possible sales of Pakistani missiles to replace the ageing Chinese CSS-2.)^[43] However, in the post-AQ Khan context, it would be surprising that such cooperation gave birth to concrete measures. At this point in time, only a Pakistani “additional guarantee” under certain circumstances appears a reasonable possibility. In the longer run, further cooperation with China could also be an option, under changed strategic circumstances. Finally, another option open to Saudi Arabia would be to fund another Muslim country’s program, as was probably the case for Pakistan’s own program and perhaps others. For the time being, Riyadh wants to show good faith and has reportedly declared its intention to forego acquisition of sensitive nuclear technologies.^[44]

Syria

Open activities make Syria a second-tier country in the field of nuclear research in the region. Damascus has two research centers which conduct such activities (Scientific Research Institute, SRI, and Der Al-Hadjar Nuclear Research Center, NRC), but they produce few publications.^[45] Its only installations declared to the IAEA are a Miniature Neutron Source and a small cyclotron. Syria has never made public any military nuclear ambition, though it has not hidden that it seeks to balance Israeli superiority by unconventional means.^[46] However, the discovery of the Al-Kibar reactor project has changed the picture. It has confirmed that a nuclear aspirant without an additional protocol into force could escape detection for several years. Also, it has revealed that North Korea was ready to embark on large-scale nuclear cooperation plans abroad. The Syrian rationale for nuclear weapons was probably to protect its territory against a U.S. or Israeli attack. If this was the case, it means that Damascus did not believe that Tehran would protect it even though the two countries probably have a mutual defense commitment.^[47] Bashar El-Asad may also have wanted to consolidate its power through such a program—which was apparently started right after he came to power.^[48] An area of concern is the question of the Syrian ability to separate plutonium. (Syrian interest for hot cells had been mentioned in the 2005 CIA Report to Congress on WMD acquisition.^[49] And it has been recently revealed that Damascus had two Chinese-provided hot cells, which are not under IAEA surveillance.)^[50] In the absence of a dedicated installation, perhaps another country was in charge of such operations; alternatively, if such a capability existed and remained undiscovered, it could be used by another country. One hypothesis to be kept in mind is Syria embarking in a second nuclear program, this time based on HEU. There were discussions between the Abdul Qadeer Khan network and Damascus on possible centrifuge procurement. Assuming these did not produce any concrete result, perhaps Syria could benefit from North Korean or Iranian assistance in this area.

Turkey

Like most Arab countries, Turkey has announced its intention to restart its civilian nuclear program. It already has a very significant nuclear infrastructure. Its main research center (Cekmece Nuclear Research and Training Center) has two modern (1986) pilot installations for conversion and fuel fabrication.^[51] The involvement of several Turkish firms in the AQ Khan network indicates that there is industrial know-how in the country which could be of use to a uranium enrichment program. However, Ankara claims to be uninterested by enrichment.^[52] The country operates two research reactors: a light-water 5 MWth reactor;^[53] and a small Triga Mark-II unit, which is being converted to operated on LEU.^[54] It also has a small waste treatment facility (Radioactive Waste Processing and Storage Facility). Scientists have made computer simulations of reprocessing with the Purex process.^[55] Generally speaking, nuclear science and technology is very active in the country. Also, Turkey is one of the only States in the region to have started setting up the regulatory mechanisms needed for larger-scale nuclear programs, under the aegis of the Turkish Atomic Energy Commission (TAEK). Turkey is moderately worried about the Iranian nuclear program. It has generally good relations with its neighbor. It is covered by a formal nuclear guarantee, backed by a multilateral alliance, and has nuclear weapons on its territory (including for use by Turkish aircraft). However, Ankara may be losing its sense of confidence about NATO. At two occasions—1991 and 2003—its allies were perceived as hesitant

to fulfill their security commitments. The new generation of Turkish officers do not trust NATO as much as the previous one.[56] In addition, political relations with the West have become more difficult because of Iraq, controversy about the 1915 events, and a European reluctance to give a clear perspective for entry into the European Union. Turkish public opinion has an extremely negative view of the United States.[57] (It is also opposed to the continued stationing of U.S. nuclear weapons.)[58] Ankara's perception of the Western security guarantee will be a key for its future nuclear choices.[59] The military option would be an extreme one: a choice in that direction would require a deepening of the crisis in confidence with both the United States and Europe. Additionally, domestic power games may come into play: a nuclear program might be a way to consolidate the place of the military in the political decision-making process. Defiance vis-à-vis Iran is stronger in the so-called "kemalist" circles.[60]

Net Assessment

An attempt to quantify the proliferation risks

A quantitative analysis, which takes into account the analysis laid out above, as well as other parameters, allows for a more fine-grained picture. What follows is a summary of a study conducted by the *Fondation pour la recherche stratégique* in 2008, which attempts to assess the likelihood of each Middle East country to go nuclear.

The quantitative analysis of the causes of proliferation has been attempted by two major studies published in 2004 and 2007.[61] These revealed interesting insights, such as a correlation between economic integration and liberalization, on the one hand, and the degree of maturation of a nuclear program, on the other. However, they did not aim at being predictive. They are also outdated since the data they used do not go beyond 1992 for the first study and 2000 for the second one.

The crude model that was used by the FRS study includes positive and negative determinants. It aims at determining what the overall assessment of each State—considered for the sake of this study as a rational and homogeneous actor—would be when thinking about going nuclear. It is important to note that in the current circumstances, unless Iran goes overtly nuclear, this would probably mean "shortening their development times" rather than actually embarking in a full-fledged nuclear weapons programs.[62] Such nuclear "hedging" may imply increasing know-how and training, import dual-use goods, conduct small-scale experiments in secret, and leaving the options of enrichment and reprocessing open.

Positive determinants that were been identified include (1) threat perception, (2) political motivations (domestic and international), (3) financial means, (4) existing nuclear installations, (5) existing nuclear experience and know-how, (6) current civilian nuclear projects, and (7) the existence of an active ballistic missile program. Negative determinants include (1) the existence of a foreign protection, (2) the degree of IAEA controls, (3) economic openness and liberalization,[63] (4) regional integration, and (5) dependence on U.S. assistance. Each of these parameters was quantified, and some of them were given a more important value than others. (For instance, the value of "threat perception" was doubled, based on the hypothesis that this factor is generally a prime driver in mature nuclear weapons programs.) The results are as follows:[64]

- Egypt (+13)
- Syria (+12)
- Algeria (+11)
- Saudi Arabia (+11)
- Turkey (+4)
- Libya (+4)

- Iraq (+2)
- United Arab Emirates (0)
- Morocco (-3)
- Tunisia (-5)
- Kuwait (-8)
- Jordan (-9)

This assessment brings three interesting lessons. The first one is that Algeria ranks in the same category as Egypt, Syria and Saudi Arabia as one of the Middle East countries most likely to go down the nuclear route. The second one is that it could have been a good predictor of a Syrian nuclear program (given that it did not take into account the Al-Kibar surprise). The third one is that Turkey ranks fairly low, contrary to many predictions.

Dynamic scenarios

This was a static analysis and of course, many future events could alter the value assigned to key parameters, thus affecting the overall results. For instance, the opportunity costs of going nuclear may be significantly affected by a change in the “supply” side of the equation. (A serious US-Pakistani or US-China crisis may affect the readiness of these countries to provide nuclear technologies to Middle Eastern countries.) An overtly nuclear Iran (which would imply a withdrawal from the NPT) would significantly affect the “threat perception” and “political motivation” parameters for several countries; if it was followed by the crumbling of the NPT/IAEA regime, the “IAEA controls” factor would conversely change. If Israel reacted to an overtly nuclear Iran by making its nuclear “coming out,” the political motivation for some countries would significantly increase. Also, external factors such as a major crisis of confidence in the U.S. protection granted to several key actors in the region would affect the “foreign protection” parameter. A conjunction of several of these events would almost certainly lead one or several of these countries to actually embark in an operation nuclear weapons program.

Then there are possible “cascading” effects. While these are sometimes overstated, they could indeed exist. For instance, it is not certain that Egypt would want to be the first Arab nuclear country—but it certainly would not want to be the second. Interesting scenarios can also be devised for the longer run. For instance, if Egypt and Algeria made moves in that direction, what conclusions would Libya draw for its own security and status? And if Saudi Arabia, Turkey and Syria were to make moves in the same direction, how would Iraq feel if it was surrounded by nuclear-capable countries?

Of course, there could also be positive dynamics. For instance, if Israel and Syria concluded a durable peace, then the risk that the latter would go nuclear would significantly diminish. However, overall, “cascading” effect seems credible in the longer run if Iran crossed the nuclear threshold.

Table 1: Known Nuclear Installations[65]

	Name	Location	Subsidiary arrangement	Date	Type and fuel	Power
ALGERIA	Nur reactor	Algiers	No	1989	Pool Light water LEU 20%	1 MWth
	Es Salam reactor	Ain Oussera	No	1992	Heavy water LEU 3%	15 MWth
	Aures-1 facility	Ain Oussera	No			
	UDEC fuel fabrication plant	Draria	No			
EGYPT	ET-RR-1 reactor	Inshas	Yes	1961	Tank Light water LEU 10%	2 MWth
	ET-RR-2 (MPR) reactor	Inshas	No	1998	Pool Light water LEU 20%	22 MWth
	NCB conversion plant	Inshas	No			
	FMPP fuel fabrication plant	Inshas	No			
	HLWMC Waste management laboratory	Inshas				
	Cyclotron HCF	Inshas				
IRAQ	C Storage site	Tuwaitha	No			
LIBYA	IRT-1 reactor	Tajura	Yes	1981	Pool Light water HEU 80% (being converted)	10 MWth
	R&D installation	Tajura	Non			

Table 1 (cont.): Known Nuclear Installations[65]

	Name	Location	Subsidiary arrangement	Date	Type and fuel	Power
MOROCCO	MA-R1 reactor			2007	TRIGA Mk-II Light water LEU	2 MWth
SYRIA	SRR-1 reactor	Damascus	Yes	1996	MNSR Light water 1 kg HEU 90%	0.03 MWth
TURKEY	TR-2 reactor	Istanbul	?[66]	1981	Pool (MTR) Light water LEU 20%	5 MWth
	ITU-TRR reactor	Istanbul	Yes	1979	TRIGA Mk-II Light water LEU (converted)	0.25 MWth
	Cekmece nuclear research and training center	Istanbul	Yes			
	Pilot conversion plant Pilot fuel fabrication plant	Istanbul	Yes	1986		

Table 2: Status of Main Conventions and Treaties[67]

	Safeguards Agreement[68]	Additional Protocol	Small Quantities Protocol	Comprehensive Test Ban Treaty	African NWFZ (Pelindaba Treaty)
Algeria	INFCIRC/531 7 January 1997	Approved by Board of Governors on 14 September 2004, not signed	-	<i>Ratified on 11 July 2003</i>	<i>Ratified on 11 February 1998</i>
Bahrein	Signed 19 September 2007, not in force	No	Yes (new), but not in force	<i>Ratified on 12 April 2004</i>	NA
Egypt	INFCIRC/302 30 June 1982	No	-	<i>Signed on 14 October 1996</i>	<i>Signed on 11 April 1996</i>
Iraq	INFCIRC/172 29 February 1972	No	-	No	NA
Iran	INFCIRC/214 15 May 1974	Signed on 18 December 2003, not ratified	-	No	NA
Israel	INFCIRC/249/Add. 1 4 April 1975	No	-	No	NA
Jordan	INFCIRC/258 21 February 1978	Yes 28 July 1998	Yes (old), in force	<i>Ratified on 25 August 1998</i>	NA
Kuwait	INFCIRC/607 7 March 2002	Yes 2 June 2003	Yes (old), in force	<i>Ratifié on 6 May 2003</i>	NA
Lebanon	INFCIRC/191 5 March 1973	No	Yes (new), in force, amended in 2007	<i>Signed on 16 September 2005</i>	NA
Libya	INFCIRC/282 8 July 1980	Yes 11 August 2006	-	<i>Ratified on 6 January 2004</i>	<i>Ratified on 11 May 2005</i>
Morocco	INFCIRC/228 18 February 1975	Signed on 22 September 2004, not ratified	Rescinded in 2007	<i>Ratified on 17 April 2000</i>	<i>Signed on 11 April 1996</i>

Table 2 (cont.): Status of Main Conventions and Treaties[67]

	Safeguards Agreement	Additional Protocol	Small Quantities Protocol	Comprehensive Test Ban Treaty	African NWFZ (Pelindaba Treaty)
Mauritania	Signed on 2 June 2003, not in force	Signed on 2 June 2003, not ratified	Yes (old), but not in force	<i>Ratified on 30 April 2003</i>	<i>Ratified on 24 February 1998</i>
Oman	INFCIRC/691 5 September 2006	No	Yes (new), in force	<i>Ratified on 13 January 2003</i>	NA
Qatar	Not yet submitted to Board of Governors	No	-	<i>Ratified on 3 March 1997</i>	NA
Saudi Arabia	Signed on 16 June 2005, not in force	No	Yes (old), in force	No	NA
Syria	INFCIRC/407 18 May 1992	No	-	No	NA
Tunisia	INFCIRC/381 13 March 1990	Signed on 24 May 2005, not ratified	-	<i>Ratified on 23 September 2004</i>	<i>Signed on 11 April 1996</i>
Turkey	INFCIRC/295 1 September 1981	Yes 17 July 2001	-	<i>Ratified on 16 February 2000</i>	NA
United Arab Emirates	INFCIRC/622 9 October 2003	No	Yes (old), in force	<i>Ratified on 18 September 2000</i>	NA
Yémen	INFCIRC/614 14 August 2002	No	Yes (old), in force	<i>Signed on 30 September 1996</i>	NA

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References

1. *In the Shadow of Iran*, International Institute for Strategic Studies (IISS), Nuclear Programmes in the Middle East, 2008, 7.
2. The analysis presented here excludes Israel and Iran.

3. Victor Gilinsky et al., [*A Fresh Examination of the Proliferation Dangers of Light Water Reactors*](#), The Non-Proliferation Education Center, October 22, 2004, 62.
4. See David Albright and Paul Brannan, "[The Al Kibar Reactor: Extraordinary Camouflage. Troubling Implications](#)," Institute for Science and International Security, May 12, 2008.
5. Richard L. Russell, "Arab Security Responses to a Nuclear-Ready Iran," in Henry Sokolski and Patrick Clawson (dir.), [*Getting Ready for a Nuclear-Ready Iran*](#) (Carlisle, PA: Strategic Studies Institute, October 2005), 57.
6. This analysis is widely shared. "The perceived reliability of U.S. security assurances will be a critical factor, if not the critical factor, in whether such countries as Japan, Saudi Arabia, South Korea, Taiwan, and Turkey reconsider their nuclear options" (Kurt M. Campbell & Robert J. Einhorn, "Avoiding the Tipping Point: Concluding Observations," in Kurt M. Campbell, Robert J. Einhorn and Mitchell Reiss (ed.), [*The Nuclear Tipping Point: Why States Reconsider Their Nuclear Choices*](#) (Washington, DC: The Brookings Institution Press, 2004), 321). "There is clear evidence in diplomatic channels that U.S. assurances to include the nuclear umbrella have been, and continue to be, the single most important reason many allies have foresworn nuclear weapons" (International Security Advisory Board, *Report on Discouraging a Cascade of Nuclear Weapons States*, October 19, 2007, 23).
7. Kenneth Katzman, [*The Persian Gulf States: Issues for U.S. Policy*](#), 2006, CRS Report For Congress, RL31533, August 21, 2006, 7.
8. An increase of military assistance to Egypt (as well as to Israel) has also been announced in 2007.
9. See Office of the Press Secretary, "[Fact Sheet: Strengthening Diplomatic Ties with Saudi Arabia](#)," The White House, May 16, 2008.
10. "Let our position be absolutely clear: An attempt by any outside force to gain control of the Persian Gulf region will be regarded as an assault on the vital interests of the United States of America, and such an assault will be repelled by any means necessary, including military force." Jimmy Carter, "[State of the Union Address: 1980](#)," January 23, 1980.
11. Peter N. Madson, [*The Sky is Not Falling: Regional Reaction to a Nuclear-Armed Iran*](#), Master's Thesis, Department of National Security Affairs, Naval Postgraduate School, Monterey, CA (March 2006): 55.
12. See [2008 Annual Arab Opinion Poll](#), Zogby International, March 2008. 73% of Saudis consider that an Iranian Bomb would have "positive" consequences for the Middle East.
13. Sammy Salama and Heidi Weber, "[The Emerging Arab Response to Iran's Unabated Nuclear Program](#)," Issue Brief, Nuclear Threat Initiative, December 22, 2006.
14. Quoted in Bruno Le Maire, *Des hommes d'Etat* (Paris: Grasset, 2007), 163.
15. Bahrain, Kuwait, Lebanon, Mauritania, Oman, Qatar, Yemen.
16. The Es-Salam reactor is configured for using 3% LEU. However, being moderated with heavy water, it could also use natural uranium. Es-Salam could produce 1 kilo of plutonium each year by using LEU, and 3 to 5 kilos using natural uranium. Such quantities could be increased by

optimizing the reactor's configuration for plutonium production ("blanketing," etc.) [IISS](#), Op. Cit., 109.

17. David Albright and Corey Hinderstein, "Algeria: Big deal in the desert?" *Bulletin of Atomic Scientists*, May-June 2001.

18. Algeria Country Profile, SIPRI; Lindsay Windsor and Carol Kessler, [Technical and Political Assessment of the Peaceful Nuclear Power Program Prospects in North Africa and the Middle East](#), Pacific Northwest Center for Global Security, PNNL-16840, Pacific Northwest National Laboratory, September 2007, 96.

19. Salama and Weber, Op. Cit.

20. Albright and Hinderstein, Op. Cit.

21. [IISS](#), Op. Cit., 110.

22. Albright and Hinderstein, Op. Cit.

23. The two international networks are ELTAM (Egypt, Libya, Tunisia, Algeria, Morocco) and EIJLST (Egypt, Iraq, Jordan, Lebanon, Syria, Turkey). [Windsor and Kessler](#), Op. Cit.

24. Wyn Q. Bowen and Joanna Kidd, "The Nuclear Capabilities and Ambitions of Iran's Neighbors," in Henry Sokolski and Patrick Clawson (dir.), [Getting Ready for a Nuclear-Ready Iran](#) (Carlisle, PA: Strategic Studies Institute, October 2005), 64.

25. [Implementation of the NPT Safeguards in the Arab Republic of Egypt](#), Report by the Director General to the Board of Governors, International Atomic Energy Agency, GOV/2005/9, February 14, 2005.

26. [Egypt Country Profile](#), SIPRI.

27. Ambassador Nabil Fahmy quoted in Peter Crail and Jessica Lasky-Fink, "[Middle Eastern States Seeking Nuclear Power](#)," *Arms Control Today*, May 2008.

28. Sammy Salama and Khalid Hilal, "[Egyptian Muslim Brotherhood Presses Government for Nuclear Weapons](#)," *WMD Insights*, November 2006.

29. Associated Press, "[Egypt refuses UN nuclear watchdog protocols for stricter inspections](#)," *The International Herald Tribune*, December 12, 2007.

30. As of 16 May 2008, Libya still retained 5 kilos of HEU. "Highly Enriched Uranium: Who Has What?" Factsheet, Monterey Center for Nonproliferation Studies, May 2008.

31. International Agency for Atomic Energy, [Implementation of the NPT Safeguards of the Socialist's People Libyan Arab Jamahiriya](#), Report by the Director General, February 20, 2004.

32. [IISS](#), Op. Cit., 105.

33. [Saudi Arabia Country Profile](#), SIPRI.

34. [Ibid.](#)

35. "[Chain Reaction: Avoiding a Nuclear Arms Race in the Middle East](#)," Report to the Committee on Foreign Relations, U.S. Senate, 110th Congress (Washington, DC : U.S. Government Printing Office, February 2008), 11.

36. [Russell](#), Op. Cit., 31.

37. [IISS](#), Op. Cit., 47.

38. Ewan MacAskill and Ian Traynor, "[Saudis consider nuclear bomb](#)," *The Guardian*, September 18, 2003. This was confirmed by a British expert who has been following the issue for a long time. Simon Henderson, "[Toward a Saudi Nuclear Option: The Saudi-Pakistani Summit](#)," *Policywatch*, no. 793, The Washington Institute for Near East Policy, October 16, 2003.

39. Roula Khalaf, Farhan Bokhari and Stephen Fidler, "Saudi Cash Joins Forces With Nuclear Pakistan," *The Financial Times*, August 5, 2004.

40. Selig S. Harrison, "[U.S. must clamp down on Pakistan nuke dealing](#)," *San Jose Mercury News*, May 30, 2003.

41. [IISS](#), Op. Cit., 37.

42. [Russell](#), Op. Cit., 32.

43. It is technically conceivable that the CSS-2 could have been mated with Pakistani warheads based on a Chinese design, despite King Fahd's assurances that they would remain conventionally-armed. But the CSS-2 force is rapidly aging.

44. U.S. Department of State, "[US Saudi Memorandum on Nuclear Energy Cooperation](#)," Communiqué, May 16, 2008.

45. Magnus Normak, et al., *Syria WMD—Incentives and Capabilities*, FOI-R-1290-SE, Stockholm, June 2004.

46. Michael Eisenstadt, "Syria's Strategic Weapons Programs," *Policy Watch*, no. 1288, The Washington Institute for Near-East Policy, September 20, 2007; "[Assad: Syria entitled to possess WMD](#)," *The Jerusalem Post*, January 6, 2004.

47. Ilan Berman, "How to Tame Tehran," *The Middle East Quarterly* (Spring 2004): 46; [IISS](#), Op. Cit., 81.

48. Office of the Director of National Intelligence (ODNI), "[Background Briefing with Senior U.S. Officials on Syria's Covert Nuclear Reactor and North Korean Involvement](#)," April 24, 2008; and [IISS](#), Op. Cit., 74.

49. Central Intelligence Agency, Unclassified Report to Congress on the Acquisition of Technologies Relating to Weapons of Mass Destruction and Advanced Conventional Munitions, January 1-December 31, 2004, November 2005.

50. [IISS](#), Op. Cit., 77.

51. The Conversion Nuclear Fuel Pilot Plant and the Pellet Production Nuclear Fuel Pilot Plant.

52. [IISS](#), Op. Cit., 66.
53. [IISS](#), Ibid., 64. The status of the TR-2 reactor is unclear.
54. As of May 16, 2008, Turkey still had 8 kilos of HEU. "Highly Enriched Uranium: Who Has What?" Factsheet, Center for Nonproliferation Studies, May 2008.
55. [IISS](#), Op. Cit., 66.
56. "[Chain Reaction: Avoiding a Nuclear Arms Race in the Middle East](#)," Op. Cit., 40.
57. "[Global Unease With Major World Powers](#)," The Pew Global Attitudes Project, June 27, 2007.
58. Opinion poll conducted by Strategic Communications Inc. for Greenpeace International, May 30, 2006.
59. Ian O. Lesser, [Turkey, Iran and Nuclear Risks](#), Nonproliferation Policy Education Center, 2004, 14.
60. [IISS](#), Op. Cit., 68.
61. Dong-Joon Jo and Erik Gartzke, "Determinants of Nuclear Weapons Proliferation," *Journal of Conflict Resolution* 48, no. 6, December 2004; Sonali Singh and Christopher Way, "The Correlates of Nuclear Proliferation. A Quantitative Test," *Journal of Conflict Resolution* 51, no. 1, February 2007.
62. International Security Advisory Board, Report on Discouraging a Cascade of Nuclear Weapons States, October 19, 2007.
63. This composite index took into account the trade/GDP ratio, the level of incoming FDI, the degree of economic liberalization, and rankings in the "globalization index."
64. Bahrain, Lebanon, Mauritania, Oman, Qatar and Yemen were left out of the analysis.
65. International Agency for Atomic Energy, Facilities under Agency Safeguards or Containing Safeguarded Material on 31 December 2006; International Agency for Atomic Energy, Research Reactors Database; World Nuclear Association, Research Reactors, May 2007.
66. The status of the TR-2 reactor is unclear.
67. International Atomic Energy Agency, NPT Comprehensive Safeguards Agreement—Overview of Status—Current Status as of 5 March 2008; Agence internationale pour l'énergie atomique, Safeguards Current Status—Status with regard to the conclusion of safeguards agreements, additional protocols and small quantities protocols (as of April 25, 2008); United Nations Organization, Office for Disarmament Affairs, Status of Multilateral Arms Regulations and Disarmament Agreements (undated, accessed May 16, 2008).
68. Date of entry into force.